LESSON 11
SHAFT EXCAVATION & CLEANING

DRILLED SHAFT FOUNDATION INSPECTION

DECEMBER 2002

LESSON 11
SHAFT EXCAVATION & CLEANING
NOTES

LESSON 11

SHAFT EXCAVATION & CLEANING

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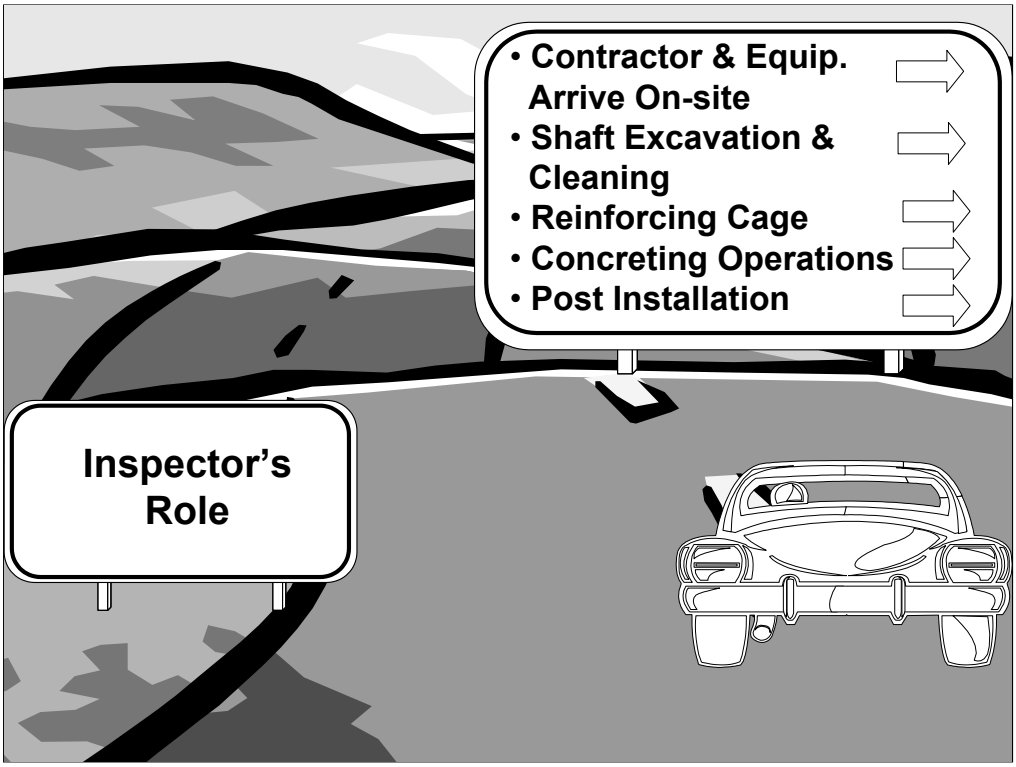
• Contractor & Equip. Arrive On-site
• Shaft Excavation & Cleaning
• Reinforcing Cage
• Concreting Operations
• Post Installation
Inspector's Role

LEARNING OBJECTIVES

- **Describe how to verify Checklist Questions 19-40**
- **Determine Shaft tip elevations**
- **Explain methods of assessing and verifying shaft cleanliness**
- **Describe the typical rock boring and shaft excavation log forms and their completion**

11-5

INSPECTOR DUTIES

Shaft Excavation and Cleaning

Responsible to:

- **Test Slurry**
- **Classify Soils & Rock**
- **Prepare Soil & Rock Excavation Logs**
- **Verify Shaft Depth**
- **Perform Shaft Inspection**
- **Prepare Shaft Inspection Log**
- **Verify hole cleanliness**
- **Document casing use, type, length**

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EXAMPLE SHAFT DEFINITIONS (PAY ITEMS)

xxx.35.1 UNCLASSIFIED EXCAVATION

xxx.35.2 CLASSIFIED EXCAVATION

xxx.35.21 STANDARD EXCAVATION

xxx.35.22 SPECIAL EXCAVATION

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xxx.35.1 UNCLASSIFIED EXCAVATION:

When drilled shaft excavation is designated as unclassified in the contract documents the Contractor shall provide the necessary equipment to remove and dispose of any materials encountered in forming the drilled shaft excavation to the dimensions shown on the plans or as directed by the Engineer. No separate payment will be made for either excavation of materials of different densities and character or employment of special tools and procedures necessary to accomplish the excavation in an acceptable fashion. Obstruction removal shall be paid separately.

xxx.35.2 CLASSIFIED EXCAVATION:

When designated in the contract documents, the Contractor shall perform classified excavation under standard and special excavation items. Obstruction removal shall be paid separately.

xxx.35.21 STANDARD EXCAVATION:

Standard excavation is excavation accomplished with conventional tools such as augers, drilling buckets, and overreaming (belling) buckets attached to drilling equipment of the size, power, torque, and down thrust (crowd) approved for use by the Engineer after successful construction of a trial drilled shaft.

xxx.35.22 SPECIAL EXCAVATION:

Special excavation is excavation that requires special tools and/or procedures to accomplish hole advancement. Special excavation is paid for excavation, except obstructions, below the depth where conventional tools and the approved drilling equipment, operating at maximum power, torque and down thrust, cannot advance the hole. All excavation, except obstructions, performed below the depth where special excavation is authorized shall be considered special excavation regardless of the density or character of materials encountered.

SAMPLE DRILLED SHAFT INSPECTION CHECKLIST

Trial Shaft		
19. Is the trial Shaft positioned away from the production shafts or as in the contract documents (xxx.13 Trial Shaft Installation)?	19	19
20. Has the contractor performed a successful test hole in accordance with xxx.31, Trial Shaft Installation?	20	20
21. Did the Contractor cut off the shaft 2 feet (0.6 m) below grade in accordance with xxx.13, Trial Shaft Installation?	21	21
22. Has the contractor revised his technique and equipment (and the revision is approved) to successfully construct a shaft?	22	22
Shaft Excavation & Cleaning		
23. Is the shaft being constructed in the correct location & within tolerance (xxx.41, Tolerances)?	23	23
24. Does the contractor have a bench mark so the shaft can be constructed and inspected to the proper elevations?	24	24
25. If a core hole is required, has the contractor taken them in accordance with xxx.35.5, Excavations?	25	25
26. If a core hole was performed, was the Rock Core Form completed and the Contractor maintained a log (xxx.35, Excavation)?	26	26
27. If the contractor is using slurry, can they perform tests and report the results in accordance with xxx.38, Slurry?	27	27
28. Is the slurry level being properly maintained in accordance with xxx.38, Slurry?	28	28
29. Is the proper type and number of tests being run on the slurry in accordance with xxx.38, Slurry?	29	29
30. Are you filling out the Soil/Rock Excavation forms?	30	30
31. If permanent casing is used, does it meet xxx.36 & 36.2, Casing?	31	31
32. If temporary casing is being used, does it meet xxx.36.1, Temporary Casing?	32	32
33. If belling is required, does it meet the requirements of xxx. 35, Excavations?	33	33
34. Is the Contractor maintaining a excavation log in accordance with xxx.35, Excavations?	34	34
35. Is the shaft within allowable Vertical alignment tolerances (xxx.41, Construction Tolerances)?	35	35
36. Is the shaft of proper depth?	36	36
37. Does the shaft excavation time meet the specified time limit (xxx.34, Excavation & Drilling Equipment)?	37	37
38. If the shaft required over reaming, was it performed in accordance with xxx.34, Excavation & Drilling Equipment?	38	38
39. Does the shaft bottom meet the requirements of xxx.40, Excavation Inspection?	39	39
40. Did you complete the Shaft Inspection Form?	40	40

SAMPLE DRILLED SHAFT INSPECTOR'S CHECKLIST

The following is a general checklist to follow when constructing a Drilled Shaft. The answer to each of these should be "yes" unless plans, specifications or specific approval has been given otherwise ***CONSULT WITH RESPONSIBLE ENGINEER FOR YOUR SPECIFIC PROJECT RESPONSIBILITIES.***

Contractor & Equipment Arrive On-Site	Yes	No	NA
1. Has the contractor submitted his drilled shaft installation plan (xxx.12, Submittals) ?	1	1	
2. Has the Drilled Shaft Installation Plan been approved ?	2	2	
3. Does the contractor have an approved concrete mix design (xxx.60, Concrete Placement)?	3	3	
4. Has the contractor run the required Trial Mix and slump loss test for his drilled shaft mix design (xxx.60, Concrete Placement)?	4	4	
5. If concreting is estimated to take over two hours, has the contractor performed a satisfactory slump loss test for the extended time period in accordance with xxx.60, Concrete Placement?	5	5	
6. If the Contractor proposed a blended minerial-polymer or a polymer slurry, do they have an approved Slurry Management Plan (xxx.38, Slurry)?	6	6	
7. Is the Contractor prepared to take soil samples or rock cores on the bottom of the shaft in accordance with xxx.35.5, Excavations?	7	7	
8. Has the contractor met the requirements of xxx.30.1, Protection of Existing Structures?	8	8	
9. Has the site preparation been completed for footing in accordance with xxx.30.2, Construction Sequence?	9	9	
10. If a cofferdam is required, does the contractor have a qualified diver and safety diver for inspections in accordance with xxx.35, Excavations?	10	10	
11. Does the contractor have all of the equipment and tools shown in his drilled shaft installation plan to install the drilled shaft?	11	11	
12. If casing is to be used, is it the correct size in accordance with xxx.36, Casing?	12	12	
13. If the contractor plans on using a manufactured slurry, does he have the equipment to mix it?	13	13	
14. Is a desander required (xxx.38, Slurry)?	14	14	
15. If a desander is required, does the contractor have it on site and operational?	15	15	
16. Does the contractor's tremie meet the requirements of xxx.61, Tremies?	16	16	
17. Do you have the required drilled shaft forms that need to be filled out during shaft construction?	17	17	
18. Do you understand the forms (if not, contact the responsible engineer for help)	18	18	
Trial Shaft			
19. Is the trial Shaft positioned away from the production shafts or as in the contract documents (xxx.13 Trial Shaft Installation)?	19	19	
20. Has the contractor performed a successful test hole in accordance with xxx.31, Trial Shaft Installation?	20	20	
21. Did the Contractor cut off the shaft 2 feet (0.6 m) below grade in accordance with xxx.13, Trial Shaft Installation?	21	21	
22. Has the contractor revised his technique and equipment (and the revision is approved) to successfully construct a shaft?	22	22	
Shaft Excavation & Cleaning			
23. Is the shaft being constructed in the correct location & within tolerance (xxx.41, Tolerances)?	23	23	
24. Does the contractor have a bench mark so the shaft can be constructed and inspected to the proper elevations?	24	24	
25. If a core hole is required, has the contractor taken them in accordance with xxx.35.5, Excavations?	25	25	
26. If a core hole was performed, was the Rock Core Form completed and the Contractor maintained a log (xxx.35, Excavation)?	26	26	
27. If the contractor is using slurry, can they perform tests and report the results in accordance with xxx.38, Slurry?	27	27	
28. Is the slurry level being properly maintained in accordance with xxx.38, Slurry?	28	28	
29. Is the proper type and number of tests being run on the slurry in accordance with xxx.38, Slurry?	29	29	
30. Are you filling out the Soil/Rock Excavation forms?	30	30	
31. If permanent casing is used, does it meet xxx.36 & 36.2, Casing?	31	31	
32. If temporary casing is being used, does it meet xxx.36.1, Temporary Casing?	32	32	
33. If belling is required, does it meet the requirements of xxx. 35, Excavations?	33	33	
34. Is the Contractor maintaining a excavation log in accordance with xxx.35, Excavations?	34	34	
35. Is the shaft within allowable Vertical alignment tolerances (xxx.41, Construction Tolerances)?	35	35	
36. Is the shaft of proper depth?	36	36	
37. Does the shaft excavation time meet the specified time limit (xxx.34, Excavation & Drilling Equipment)?	37	37	
38. If the shaft required over reaming, was it performed in accordance with xxx.34, Excavation & Drilling Equipment?	38	38	
39. Does the shaft bottom meet the requirements of xxx.40, Excavation Inspection?	39	39	
40. Did you complete the Shaft Inspection Form?	40	40	

19. Is the trial shaft positioned away from the production shafts or as in the contract documents (xxx. 13 Trial Shaft Installation)?

XXX.13 TRIAL SHAFT INSTALLATION

- **Away from production shafts**
- **Extend to maximum anticipated depth of production**

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XXX.13 TRIAL SHAFT INSTALLATION

The Contractor shall demonstrate the adequacy of his methods, techniques and equipment by successfully constructing an unreinforced concrete, trial shaft in accordance with this specification's requirements. This trial shaft shall be positioned away from production shafts in the location shown on the plans or as directed by the Engineer. The trial shaft shall be drilled to the maximum depth of any production shaft shown in the plans. When shown on the plans, the reaming of bells at specified trial shaft holes will be required to establish the feasibility of belling in a specific soil stratum….

Commentary

Trial shaft holes should be located either at least three shaft diameters or one bell diameter, whichever is greater, from a permanent shaft location. The diameter and depth of the trial shaft hole or holes should be the same as the diameter and depth of the production drilled shafts. The trial shaft holes will generally be filled with unreinforced concrete in the same manner that production shafts will be constructed. In some cases, the trial shaft holes may be backfilled with suitable soil when concreting problems are not anticipated for production shafts

20. Has the Contractor performed a successful test hole in accordance with xxx. 13 Trial Shaft Installation?

XXX.13 TRIAL SHAFT INSTALLATION

- **Contractor must complete a successful trial shaft**
- **If proposed method unsuccessful, must modify and be approved by the Engineer**

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XXX.13 TRIAL SHAFT INSTALLATION

….Failure by the Contractor to demonstrate to the Engineer the adequacy of methods and equipment shall be reason for the Engineer to require alterations in equipment and/or method by the Contractor to eliminate unsatisfactory results….

Commentary

Site-specific reasons to construct trial shafts include determining if the Contractor can: control dimensions and alignment of excavations within tolerance; seal the casing into impervious materials; control the size of the excavation under caving conditions by the use of a mineral or polymer slurry or by other means; properly clean the completed shaft excavation; construct excavations in open water areas; or satisfactorily execute any other necessary construction operation.

21. Did the Contractor cut off the shaft 2.0 ft (0.6 m) below grade in accordance with xxx. 13 Trial Shaft Installation?

XXX.13 TRIAL SHAFT INSTALLATION

- **Reinforcement cage may or may not be installed in trial shaft**
- **Cutoff 2 ft. (0.6 m) below finished grade when completed**

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XXX.13 TRIAL SHAFT INSTALLATION

…Unless otherwise shown in the contract documents, the trial shaft holes will be filled with unreinforced concrete in the same manner that production shafts will be constructed. The concreted trial shafts shall be cut off 2 feet (0.6 m) below finished grade and left in place….

22. Has the Contractor revised his techniques and equipment (and the revision is approved) to successfully construct the shaft?

XXX.13 TRIAL SHAFT INSTALLATION

- **No changes permitted once approved, based upon trial shaft**

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XXX.13 TRIAL SHAFT INSTALLATION

…..Any additional trial holes required to demonstrate the adequacy of altered methods or construction equipment shall be at the Contractor's expense. Once approval has been given to construct production shafts, no changes will be permitted in the methods or equipment used to construct the satisfactory trial shaft without written approval of the Engineer…

INSPECTOR DUTIES FOR TRIAL SHAFT

The Inspector's responsibilities are the same during the Test Shaft Installation as in the Production Shaft installation.

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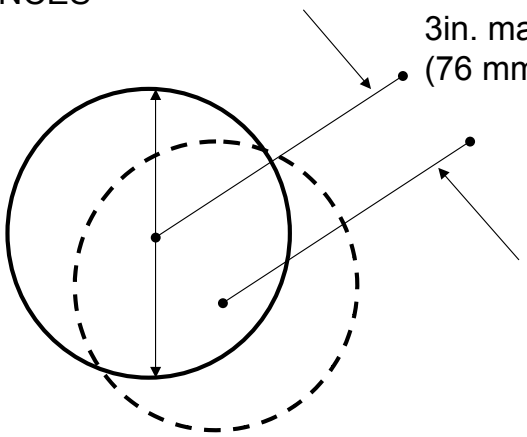
23. Is the shaft being constructed in the correct location & within tolerance (xxx.41, Tolerances)?

xxx.41 TOLERANCES

Plan Position



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xxx.41 TOLERANCES

…. The following construction tolerances apply to drilled shafts unless otherwise stated in the contract documents:

a.) The center of the drilled shaft shall be within 3 inches (76 mm) of plan position in the horizontal plane at the plan elevation for the top of the shaft….

24. Does the Contractor have a bench mark so that the shaft can be constructed and inspected to the proper elevations?

- **The Contractor should provide an elevation and item (template or casing) to use as a reference.**
- **Preferably fixed and stable.**

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It is extremely important that the reference point and elevation provided to the Inspector by the Contractor be stable and fixed.

25. If a core hole is required, has the contractor taken them in accordance with xxx.35.5, Excavations?

xxx.35.5 EXCAVATIONS

- **Before or after excavation**
- **Minimum of 10 ft. (3 m) below bottom of shaft elevation**
- **Rock cores or split-spoons**

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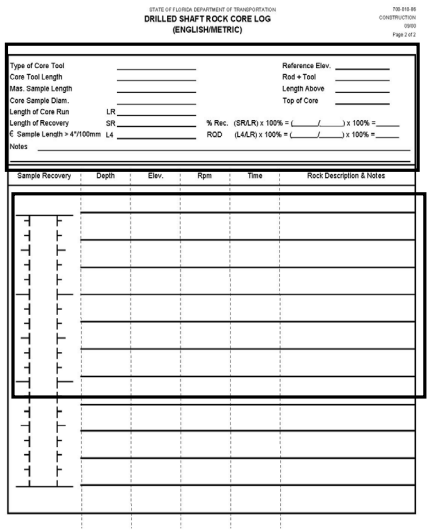
xxx.35.5 EXCAVATIONS

…..The soil samples shall be extracted with a split spoon sampler or undisturbed sample tube. The rock cores shall be cut with an approved double or triple tube core barrel to a minimum of 10 feet (3 m) below the bottom of the drilled shaft excavation either before the excavation is made or at the time the shaft excavation is approximately complete. The Engineer may require the depth of coring to be extended up to a total depth of 20 feet (6 m). Rock core and standard penetration test samples shall be measured, visually identified and described on the Contractor's log….

26. If the core hole was performed, was the Rock Core Form completed and the Contractor maintained a log (xxx.35 Excavations)?


STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

DRILLED SHAFT ROCK CORE LOG
(ENGLISH/METRIC)

700-010-06
CONSTRUCTION
09/00
Page 2 of 2

Type of Core Tool
Core Tool Length
Mbs. Sample Length
Core Sample Diam.
Length of Core Run
Length of Recovery
Σ Sample Length > 4"/100mm
Notes

LR
SR
L4

Reference Elev.
Rod + Tool
Length Above
Top of Core

% Rec. (SR/LR) x 100% = (_____/_____) x 100% = _____
ROD (L4/LR) x 100% = (_____/_____) x 100% = _____

Sample Recovery	Depth	Elev.	Rpm	Time	Rock Description & Notes

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xxx. 35.5 EXPLORATION (SHAFT EXCAVATION)

…If the samples are acquired when the excavation has reached the planned elevation of the shaft base, the field log and samples shall be delivered to the Engineer immediately upon completion, and the Engineer shall inspect the materials and render a decision on the suitability of the bearing stratum without delay. If the samples are acquired prior to making the excavation, the samples and field log shall be delivered to the Engineer within 24 hours after the exploration is complete….

SAMPLE

DRILLED SHAFT ROCK CORE LOG
(ENGLISH/METRIC)

CONSTRUCTION
09/00
Page 2 of 2

Type of Core Tool _____ Reference Elev. _____
Core Tool Length _____ Rod + Tool _____
Mas. Sample Length _____ Length Above _____
Core Sample Diam. _____ Top of Core _____
Length of Core Run LR _____
Length of Recovery SR _____ % Rec. (SR/LR) x 100% = (_____/_____) x 100% = _____
€ Sample Length > 4"/100mm L4 _____ RQD (L4/LR) x 100% = (_____/_____) x 100% = _____
Notes _____

Sample Recovery	Depth	Elev.	Rpm	Time	Rock Description & Notes

27. If the contractor is using slurry, have they tested the slurry and reported the results in accordance with xxx.38, Slurry?

xxx.38 SLURRY

- **Contractor responsible for performing tests**
- **Reports of tests to Engineer**

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xxx.38 SLURRY

….. Control tests using suitable apparatus shall be carried out on the mineral slurry by the Contractor to determine density, viscosity and pH….

….Reports of all tests required above signed by an authorized representative of the Contractor, shall be furnished to the Engineer on completion of each drilled shaft….

28. Is the slurry level being properly maintained in accordance with xxx.38, Slurry?

xxx.38 SLURRY

Mineral Slurry
• Level maintained at no less than 4.0 ft. (1.2 m) above highest piezometric pressure level

Polymer Slurry
• Level maintained at no less than 6.0 ft. (1.8 m) above highest piezometric pressure level

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xxx.38 SLURRY

…. During construction, the level of mineral or blended mineral-polymer slurry in the shaft excavation shall be maintained at a level not less than 4 feet (1.2 m) above the highest expected piezometric pressure head along the depth of the shaft, and the level of polymer slurry shall be maintained at a level not less than 6 feet (1.8 m) above the highest expected piezometeric pressure head along the shaft…

Commentary

Whether mineral or polymer slurry is used, it is essential that the provision that the slurry head remain above the piezometric head in the formation be strictly enforced. This especially includes initial drilling of the borehole down to the piezometric level. Slurry should be introduced when the depth of the borehole is still above the piezometric level, not after the inflow of water can be detected and/or sloughing has begun. It is good to have continuous knowledge of the current elevation of the piezometric surface which should be noted on the Report of Core Borings sheet in the plans.

29. Is the proper type and number of tests being run on the slurry in accordance with xxx.38, Slurry?

xxx.38 SLURRY

- **Set of Tests**
  - **Density**
  - **Viscosity**
  - **pH**
- **4 sets of tests first 8 hours**
- **1 set every four hours, if within acceptable range**

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xxx.38 SLURRY

…Tests to determine density, viscosity and pH value shall be performed during the shaft excavation to establish a consistent working pattern. A minimum of four sets of tests shall be made during the first 8 hours of slurry use. When the results show consistent behavior the testing frequency may be decreased to one set every four hours of slurry use….

29. Is the proper type and number of tests being run on the slurry in accordance with xxx.38, Slurry? (Continued)

xxx.38 SLURRY

- **Sampling & testing required just prior to concrete placement**
- **Sampler must be approved by Engineer**
- **Sample from base of shaft up at <10 ft. (3 m) intervals**

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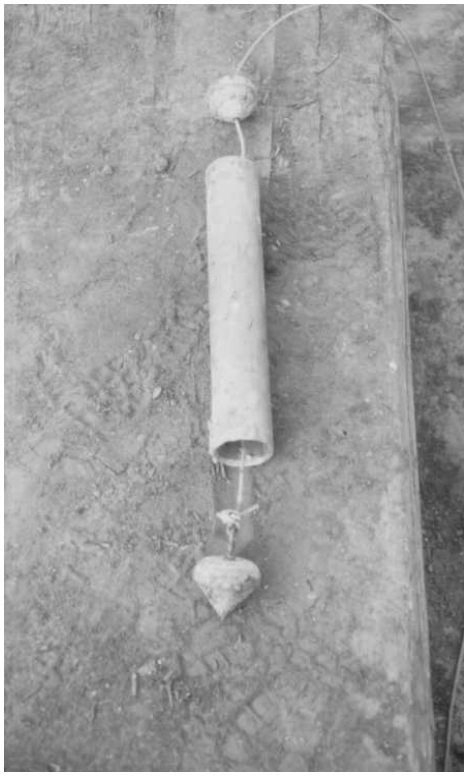
xxx.38 SLURRY

…The Contractor shall insure that a heavily contaminated slurry suspension, which could impair the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the Contractor shall take slurry samples using a sampling tool approved by the Engineer. Slurry samples shall be extracted from the base of the shaft and at intervals not exceeding 10 feet (3 m) up the slurry column in the shaft…

SLURRY SAMPLING

Sampler



…..two consecutive samples produce acceptable values….

SLURRY TESTING- BENTONITE/ATTAPULGITE			
Item to be measured	**Range of Values @ Time of Slurry Introduction**	**Range of Values @ Time of Concreting**	**Test Method**
Density	63.4* - 69.1* pcf 10.1* - 10.8* kN/m^3	64.3* – 75.0* pcf 10.1* - 11.8* kN/m^3	Mud density balance API-13B-1; Section 1
Viscosity	28 to 45 sec/quart**	28 to 45 sec/quart**	Marsh Cone Method API-13B-1; Section 2.2
pH	8 - 11	8 - 11	Electric pH meter or pH indicator paper strips
Sand Content	4%or less	4%or less***	API-13B-1

***Increase by 2 pcf (0.31 kN/m^3) in salt water**
**** Standard measurements are in seconds per quart**
***** 1% at base of drilled shaft excavation for polymer slurries**

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xxx.38 SLURRY

…Slurry samples shall be extracted from the base of the shaft and at intervals not exceeding 10 feet (3 m) up the slurry column in the shaft, until two consecutive samples produce acceptable values for density, viscosity, and pH….

Mineral slurry ….Desanding equipment shall be provided by the Contractor as necessary to control slurry sand content to less than 4 percent by volume at any point in the borehole…..

Polymer… whatever product is used, the sand content at the base of the drilled shaft excavation shall not exceed 1 per cent when measured…..immediately prior to concreting.

This guide specification does not include a table of acceptable values for density, viscosity and pH for polymer or blended mineral-polymer slurries. This is because the proper operating ranges for those properties vary considerably with specific polymers.

WATER AS A DRILLING FLUID

Can the Contractor use water as a drilling fluid?

11-26

TYPICAL PROBLEMS

• ***Bulge or neck in shaft***- Soft ground zones that were not cased or slurry improperly maintained.

• ***Cave in of shaft walls***- Improper use of casing or slurry; failure to use weighting agents in bentonite in running ground water.

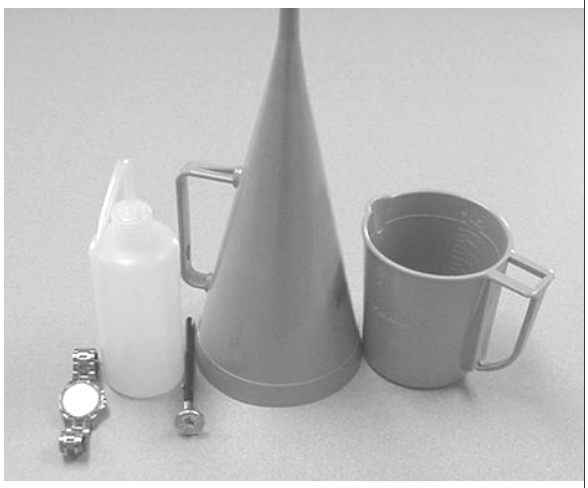
• ***Excessive mudcake buildup***- Failure to aggitate slurry or to place concrete in a timely manner.

11-27

SLURRY TESTING

Viscosity Test

- **Also known as Marsh Funnel Test**
- **Measures the flow rate (I.e. consistency)**

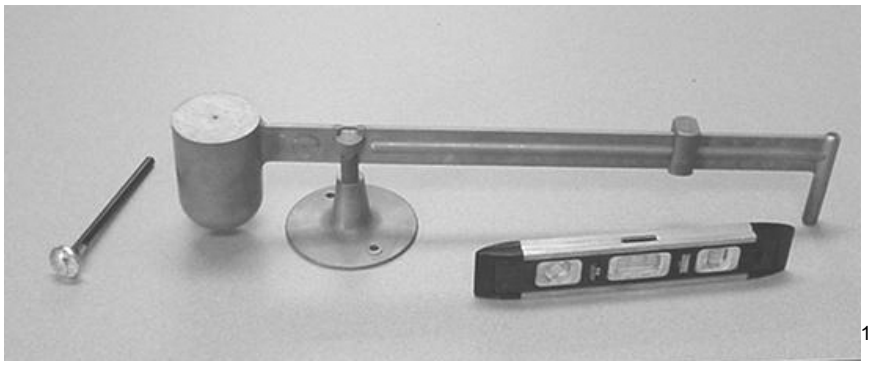


11-29

The viscosity test is also known as the Marsh Funnel. This test is performed on the pre-mixed slurry prior to introduction in the hole and consists basically of measuring the time required for a prescribed amount of slurry to pass through a plastic funnel with a standard size orifice. The funnel is held in an upright position with the outlet sealed by one's hand or finger. The test sample is poured through the screen at the top of the funnel until the mud level just reaches the underside of the screen. A stop watch is used to measure the time for a prescribed amount of mud to exit the funnel with the results measured in seconds. As a comparative number, clear water would generally have a test result of 26 seconds.

Mud Balance Test

- **Also known as Mud Density Test**
- **Measures the density (i.e. weight)**



11-30

The second test prescribed for the pre-mixed slurry, and a test that may also be used for testing samples from the actual excavation, is the density test or mud balance. This device is standardized such that a prescribed amount of mud can be added to a cup attached to a balance arm which rests across a fulcrum. Readings can be taken directly on the scale depending on the weight of mud contained in the cup. The procedures for this test are outlined in the following:

1. Fill the cup with mud to be weighed.

2. Place the lid on the cup and seat it firmly but slowly with a twisting motion. Be sure some mud runs out of the hole in the cap.

3. With the hole in the cap covered with a finger, wash or wipe down all mud from the outside of the cup and arm.

4. Set the knife on the fulcrum and move the sliding weight along the graduated arm until the cup and arm are balanced.

5. Read the density of the mud at the left hand edge of the sliding weight.

pH

- **For determining the acidity and alkalinity content of the slurry mix**
- **Reported as number value (1-14)**

11-31

Sand Content Test

- **For determining the sand content of the slurry mix**
- **Reported in volume percent**

11-32

A more complex test is required when the sand content must be determined. The equipment required for this test consists of a 200 mesh sieve, a small funnel and a sand content tube. The test procedure is prescribed as follows:

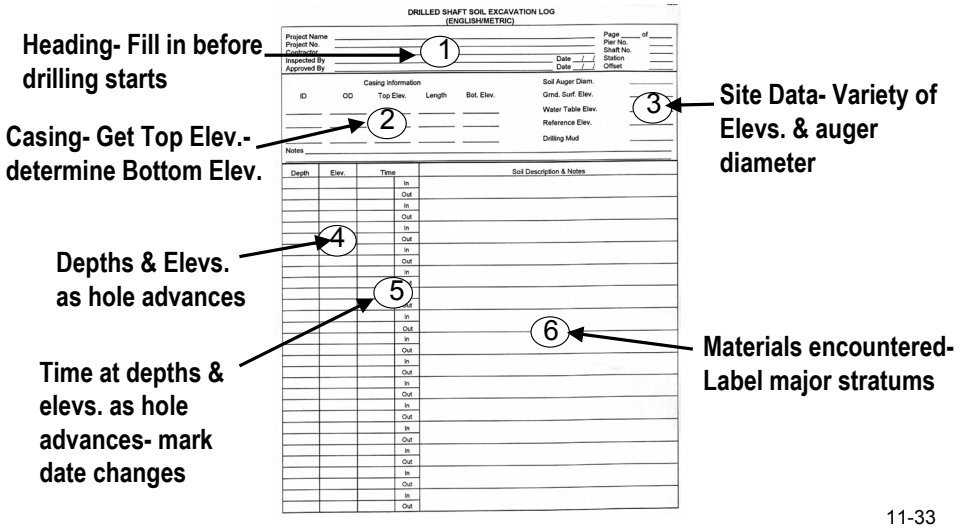
1. Fill the sand content tube to the indicated mark with mud. Add water to next mark. Close mouth of the tube and shake vigorously
.
2. Pour the mixture onto the clean, wet screen. Discard the liquid passing through the screen. Add more water to the tube, shake, and again pour onto the screen. Repeat until the wash water passes through clear. Wash the sand retained on the screen to free it of any remaining mud.

3. Fit the funnel upside down over the top of the screen. Slowly invert the assembly and insert the tip of the funnel into the mouth of the tube. Wash the sand into the tube by spraying a fine spray of water through the screen. (Tapping on the side of the screen with a spatula handle, may facilitate this process). Allow the sand to settle, from the gradations on the tube, read the volume percent of the sand.

4. Report the sand content of the mud in volume percent.

30. Are you filling out the Soil/Rock Excavation forms?

Completing the Drilled Shaft Soil/Rock Log



11-33

Fill in every blank on the form. If it does not apply, put an "N/A" or a long dash. Use pencil -- but never erase. If you need to change something, strike a single line through the item and insert the correct information above it. If there is insufficient room to make a note, footnote the item and go to the bottom of the page, or use a separate page.

1. Heading : - Fill in <u>before</u> drilling starts.
   - Be sure to print your name & the start date of drilling.
   - The Geotechnical Engineer will sign approval line.
   - Record from Key Sheet (station & offset not applicable)

2. Casing:- Measure in inches (millimeters) in field.
   - Surveyor provides Top of Casing Elevation
   - Compute bottom elevation: *TE – L = BE*

3. Site Data: - Soil Auger dia. - measure & record in inches (millimeters)
   - Ground surface elev. - provided by surveyor
   - Water table elev. - measure w/tape in hole before slurry is introduced.
   WT may need to be estimated from seepage in dry hole method
   - Ref elev. - provided by surveyor
   - Drill mud - observe & record; compare to Installation Plan.

4. Depth / Elevation: **Depth** can be measured by either:
   1) Contractor has kelly bar marked
   2) Weighted tape

   Reference elevation is always known; i.e. template or top of casing.

   Elevation - compute *TE – D = E*
   Enter Depth/Elev. EVERY TIME tools come out of hole.

5. Time : May use military or 24 hr clock. Be consistent & correct!

6. Material: Use this form to record all activity during shaft excavation. Prepare soil profile expected from Soils Classification Sheet in the Project Plans. Label major strata. Use this labeling on Excavation Log so long as materials are the same.

SAMPLE

DRILLED SHAFT SOIL EXCAVATION LOG
(ENGLISH/METRIC)

Project Name ____________________ Page _____ of _____
Project No. ____________________ Pier No. _____
Contractor ____________________ Shaft No. _____
Inspected By ____________________ Date __/__/__ Station _____
Approved By ____________________ Date __/__/__ Offset _____

Casing Information

ID	OD	Top Elev.	Length	Bot. Elev.

Soil Auger Diam. _____
Grnd. Surf. Elev. _____
Water Table Elev. _____
Reference Elev. _____
Drilling Mud _____

Notes ____________________

Depth	Elev.	Time		Soil Description & Notes
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	
			In	
			Out	

31. If permanent casing is used, does it meet xxx.36 & 36.2, Casing?

xxx. 36 CASINGS

- **Steel, smooth, clean & watertight**
- **OD not less than specified shaft diameter**

xxx. 36.2 PERMANENT CASINGS

- **Used when shown in the plans**
- **Continuous between top and bottom**

11-35

FHWA Publication IF-99-025

xxx.36 CASINGS

Casings shall be steel, smooth, clean, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of casing shall not be less than the specified diameter of shaft, and the outside diameter of any excavation made below the casing shall not be less than the specified diameter of the shaft….

xxx. 36.2 PERMANENT CASINGS

Permanent casing shall be used when shown in the contract documents. The casing shall be continuous between top and bottom elevations prescribed in the plans. After installation is complete, the permanent casing shall be cut off at the prescribed elevation and the shaft completed by installing necessary reinforcing steel and concrete in the casing.

32. If temporary casing is being used, does it meet xxx.36.1, Temporary Casing?

xxx. 36.1 TEMPORARY CASINGS

- **All casing considered Temporary unless shown in the plans**
- **Shall be removed before completion of concreting**

11-36

FHWA Publication IF-99-025

xxx. 36.1 TEMPORARY CASINGS

…All subsurface casing shall be considered temporary unless specifically shown as permanent casing in the contract documents. The Contractor shall be required to remove temporary casing before completion of concreting the drilled shaft. Telescoping, predrilling with slurry, and/or overreaming to beyond the outside diameter of the casing may be required to install casing….

Commentary

Temporary casing is commonly installed through an unstable deposit in an overreamed hole by the wet method and sealed in an underlying impervious layer. This procedure traps drilling fluid between the casing and the borehole wall. This trapped drilling fluid must be displaced upward along the outside of the casing during casing extraction if the load support capacity of this deposit is to be mobilized and the structural integrity of the shaft is to be ensured.

Positive upward displacement of drilling fluid can only be achieved if an adequate head of fluid concrete fills the casing when the seal is broken during casing extraction. In general, the head of concrete should be kept at or above hydrostatic ground water level during casing extraction. This requires adding concrete during extraction, as the volume to fill the overreamed hole is greater than the casing volume. Casing should never be pulled after the concrete begins to set due to probable entrapment of drilling fluid in the shaft concrete and probable separation of the concrete within the shaft.

COMMON PROBLEMS

• ***Temporary casing that cannot be removed-*** In some cases, specially squeezing ground conditions, the crane handling the casing doesn't have the power to pull the casing.

• ***Horizontal separation or severe necking-*** This shaft problem can occur if the temporary casing has concrete adhering to it when pulled.

11-37

33. If belling is required, does it meet the requirements of xxx. 35, Excavations?

xxx. 35 EXCAVATIONS

- **Size and shape shown in plans**
- **Excavated by mechanical means**

11-38

FHWA Publication IF-99-025

xxx. 35 EXCAVATIONS

…When shown in the plans, bells shall be excavated to form the height and bearing area of the size and shape shown. The bell shall be excavated by mechanical methods. Any drilled shaft concrete over the theoretical amount required to fill any excavations for the bells and shafts dimensioned on the plans shall be furnished at the Contractor's expense…

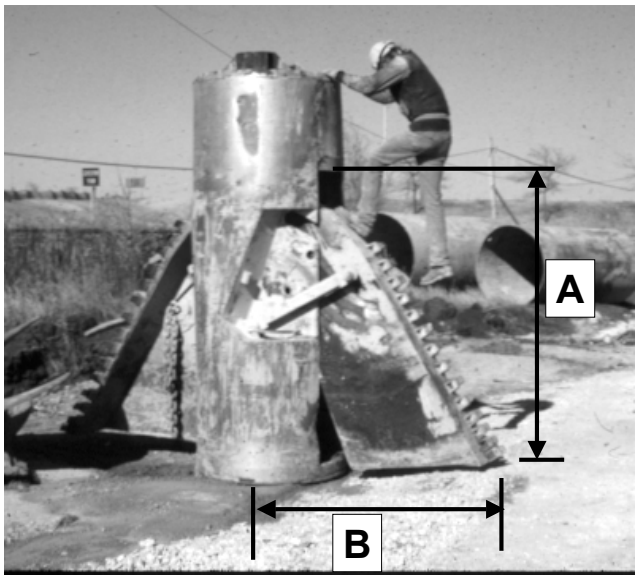
BELLING TOOL

Field Verification of Bell Angle

For

45º: **A & B should be equal**

60º: **A = 2 X B**



34. Is the Contractor maintaining a excavation log in accordance with xxx.35, Excavations?

xxx.35 EXCAVATIONS

- **Contractor shall maintain log**
- **Log soil/rock types and thickness**
- **Note groundwater/seepage**
- **Note equipment**

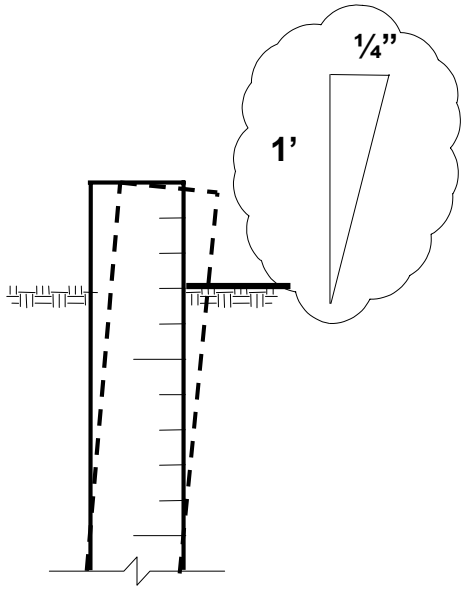
11-40

FHWA Publication IF-99-025

xxx.35 EXCAVATIONS

…The Contractor shall maintain a construction method log during shaft excavation. The log shall contain information such as: the description and approximate top and bottom elevation of each soil or rock material encountered, seepage or ground water, and remarks, including a description of the tools and drill rigs used and any changes necessitated by changing ground conditions….

35. Is the shaft within allowable vertical alignment tolerances (xxx.41, Construction Tolerances)?

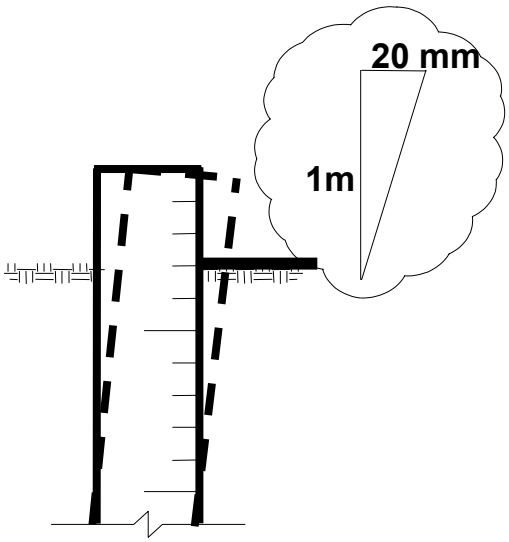


11-41

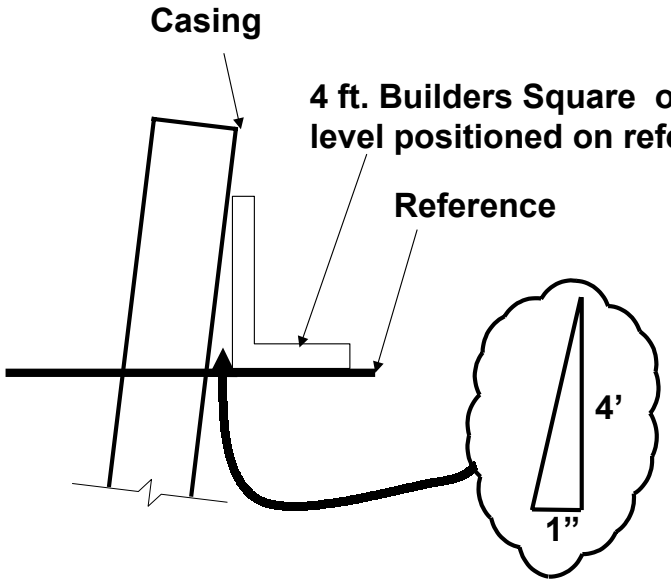
FHWA Publication IF-99-025

xxx.41 CONSTRUCTION TOLERANCES

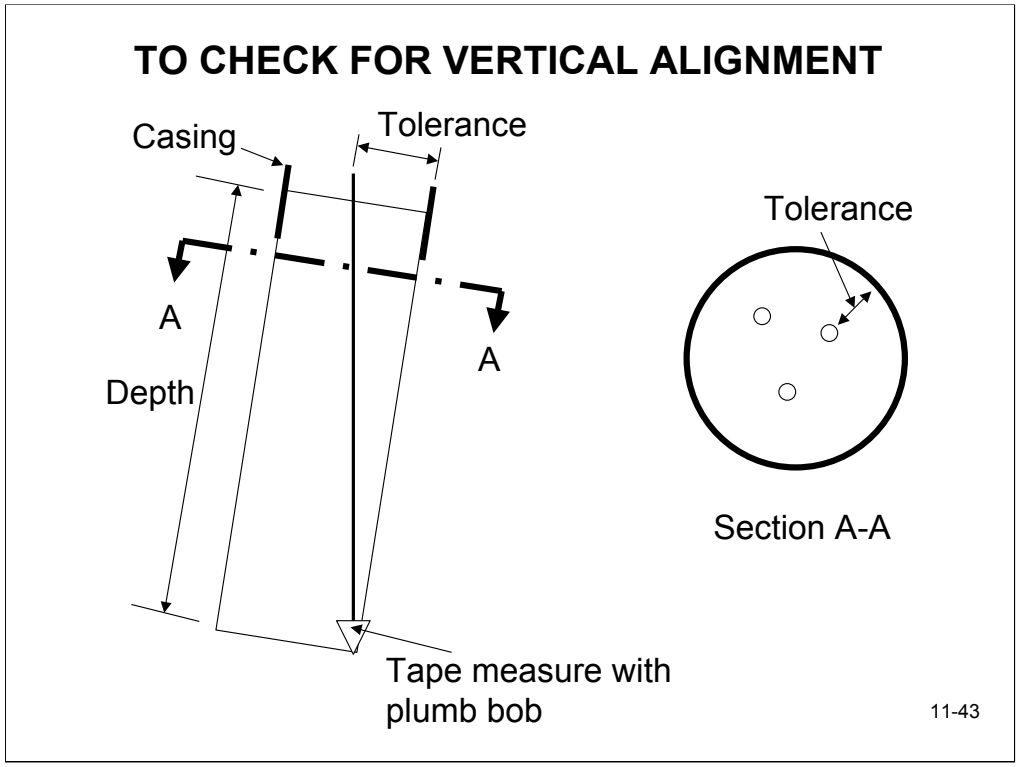
….The vertical alignment of a vertical shaft excavation shall not vary from the plan alignment by more than 1/4 inch per foot (20 mm per meter) of depth. The alignment of a battered shaft excavation shall not vary by more than 1/2 inch per foot (40 mm per meter) of the distance along the axis of the shaft from the prescribed batter…



TO CHECK FOR VERTICAL ALIGNMENT



11-42



Plump Bob Method

If you know the vertical tolerance, which we do (1/4”/ft or 20 mm/m) then you can use this method to determine vertical tolerance of plumb shafts.

Assume shaft in illustration is 50 ft. in depth.

1. Determine Tolerance; ¼”/ft., therefore, .25” x 50 ft. = 12.5”
2. Measure in from casing towards center of shaft 12.5”- lower plumb bob
3. When plumb bob makes contact, note measurement.
4. Do this at several locations around shaft.
5. In our scenario, any measurement less than 50 ft. would indicate and out of alignment shaft.

Note- we are assuming the shaft is clean and there is no significant accumulation of sediment or cuttings on the bottom.

LEARNING OBJECTIVE # 1

Describe how to verify Checklist Questions 19-40

What is the allowable tolerances for plan position for a vertical shaft?

What is the allowable tolerances for vertical alignment for a vertical shaft?

11-44

LEARNING OBJECTIVE # 1

Describe how to verify Checklist Questions 19-40

The Contractor proposes to use a polymer slurry. How high above the piezometric level must they maintain the slurry ?

When using bentonite or attapulgite slurry, what is the maximum sand content permitted in the slurry?

11-45

LEARNING OBJECTIVE # 1

Describe how to verify Checklist Questions 19-40

How many sets of tests are to be performed within the first 8 hours of slurry use ?

Slurry samples are to be obtained at what intervals up the slurry column for testing?

11-46

36. Is the shaft of proper depth?

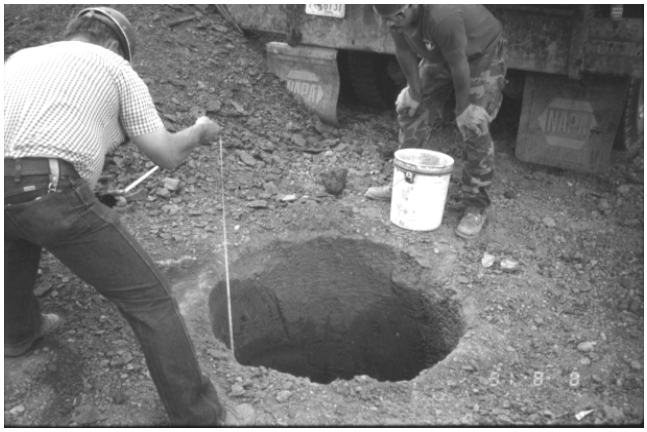
- **Generally determined and verified by lowering a weighted tape down to the bottom of the shaft after cleaning or**
- **Contractor's marks on the kelly.**
- **Typically measured and recorded to the nearest 0.1 or 0.01 foot from the supplied reference. Check specifications for degree of accuracy,**

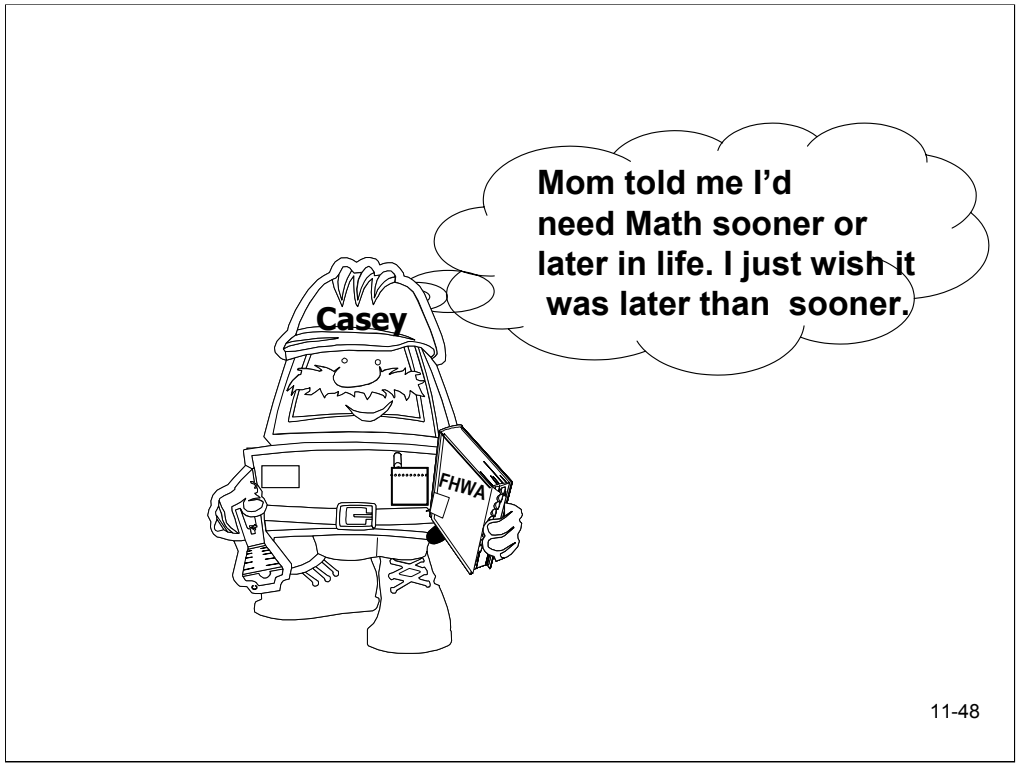
11-47

FHWA Publication IF-99-025

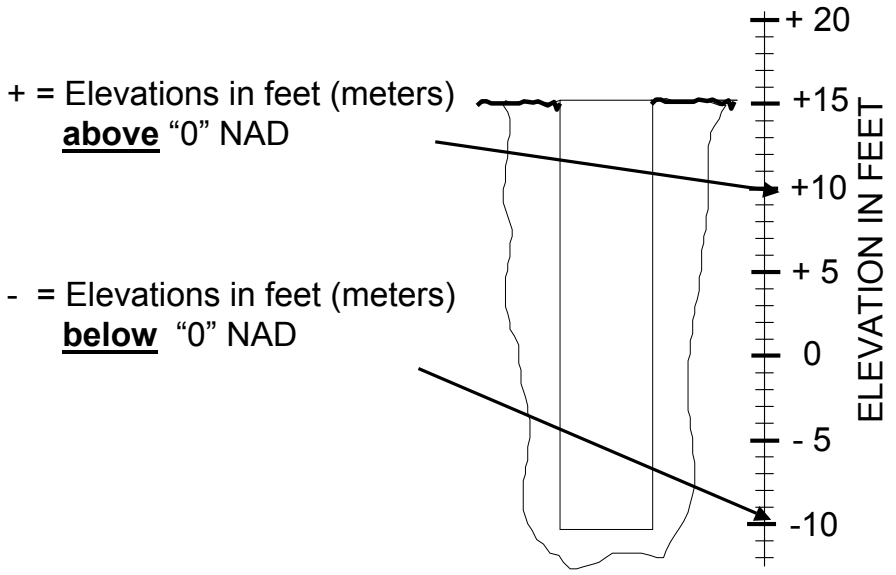
xxx.40 EXCAVATION INSPECTION:

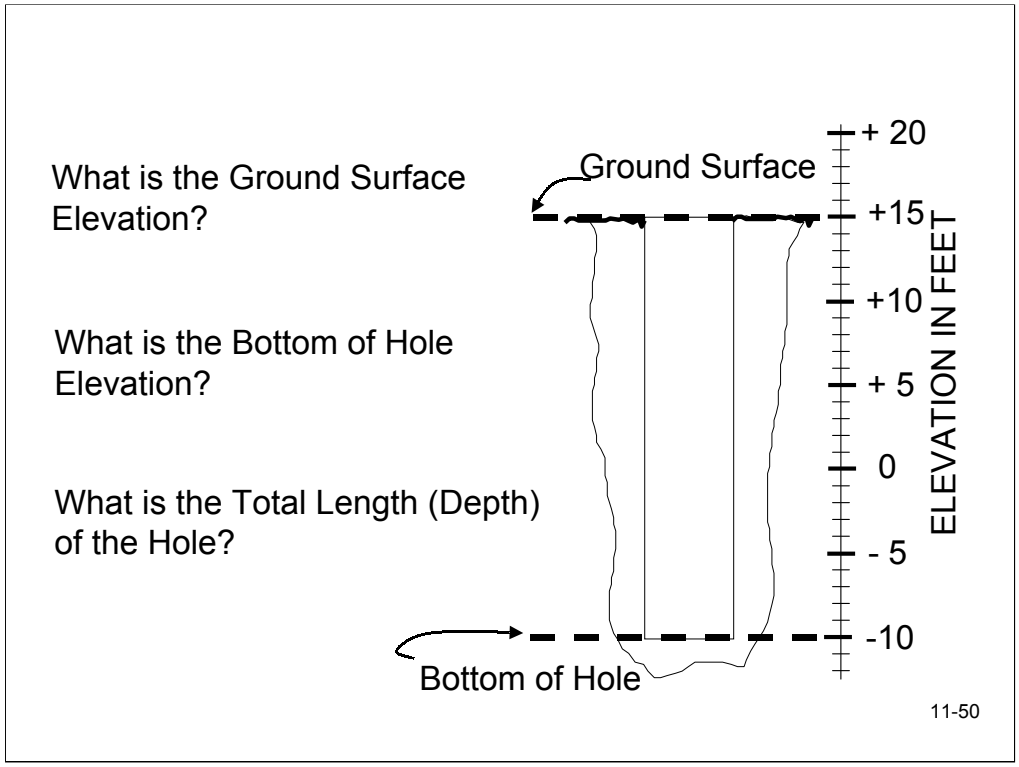
The Contractor shall provide equipment for checking the dimensions and alignment of each shaft excavation. The dimensions and alignment shall be determined by the Contractor under the direction of the Engineer. Final shaft depths shall be measured with a suitable weighted tape or other approved methods after final cleaning……




Mom told me I'd need Math sooner or later in life. I just wish it was later than sooner.
Casey
FHWA
11-48

Working with Elevations

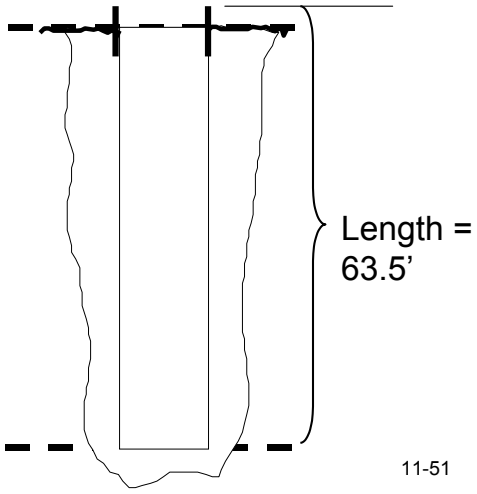



What is the Ground Surface Elevation?
What is the Bottom of Hole Elevation?
What is the Total Length (Depth) of the Hole?
Ground Surface
Bottom of Hole
+ 20
+15
+10
+ 5
0
- 5
-10
ELEVATION IN FEET
11-50

LEARNING OBJECTIVE #2
Determine Shaft tip elevations

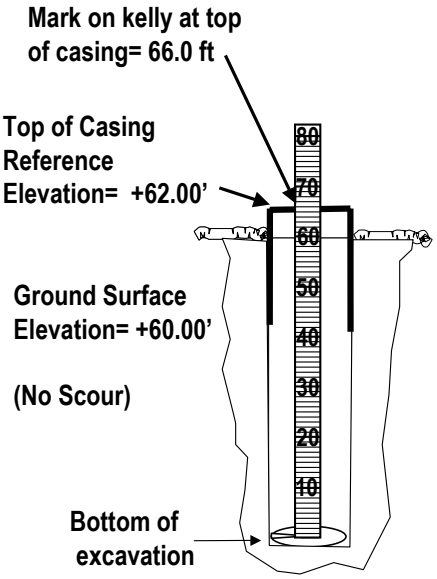
Top of Casing Ref. = El. + 27.3’

What is the Bottom of Hole Elevation?



11-51

LEARNING OBJECTIVE #2
Determine Shaft tip elevations



Plumb Shaft
Determine Tip Elev.

Tip elevation is the Reference elev. minus the Vertical length of shaft below the reference.

11-52

37. Does the shaft excavation time meet the specified time limit (xxx.34, Excavation & Drilling Equipment)?

xxx.34 EXCAVATION & DRILLING EQUIPMENT

- **Sidewall overreaming required when:**
  - **Shaft sides have softened**
  - **Shaft sides have swelled**
  - **Shaft sides sloughing**

11-53

FHWA Publication IF-99-025

xxx.34 EXCAVATION & DRILLING EQUIPMENT

….Sidewall overreaming shall be required when the sidewall of the hole is determined by the Engineer to have either softened due to excavation methods, swelled due to delays in concreting, or degraded because of slurry cake buildup….

38. If the shaft required over reaming, was it performed in accordance with xxx.34, Excavation & Drilling Equipment?

xxx.34 EXCAVATION & DRILLING EQUIPMENT

- **Minimum ½ inch (12.7 mm)**
- **Maximum 3 inches (75 mm)**
- **As directed by the Engineer**

11-54

FHWA Publication IF-99-025

xxx.34 EXCAVATION & DRILLING EQUIPMENT

…. Overreaming thickness shall be a minimum of 1/2 inch (12.7 mm) and a maximum of 3 inches (75 mm). Overreaming may be accomplished with a grooving tool, overreaming bucket or other approved equipment. The thickness and elevation of sidewall overreaming shall be as directed by the Engineer. The Contractor shall bear all costs associated with both sidewall underreaming and additional shaft concrete placement….

39. Does the shaft bottom meet the requirements of xxx.40, Excavation Inspection?

xxx.40 EXCAVATION INSPECTION

• Minimum of 50% of shaft base will have less than ½ inch (12.7 mm) of sediment

11-55

FHWA Publication IF-99-025

xxx.40 EXCAVATION INSPECTION

….Final shaft depths shall be measured with a suitable weighted tape or other approved methods after final cleaning. Unless otherwise stated in the plans, a minimum of 50 per cent of the base of each shaft will have less than 1/2 inch (12.7 mm) of sediment at the time of placement of the concrete. …

39. Does the shaft bottom meet the requirements of xxx.40, Excavation Inspection? (Continued)

xxx.40 EXCAVATION INSPECTION

- **Maximum depth of sediment or debris = 1 ½" (38 mm)**
- **Dry Shafts no more than 3" (75 mm) of water**
- **Determination by Engineer**

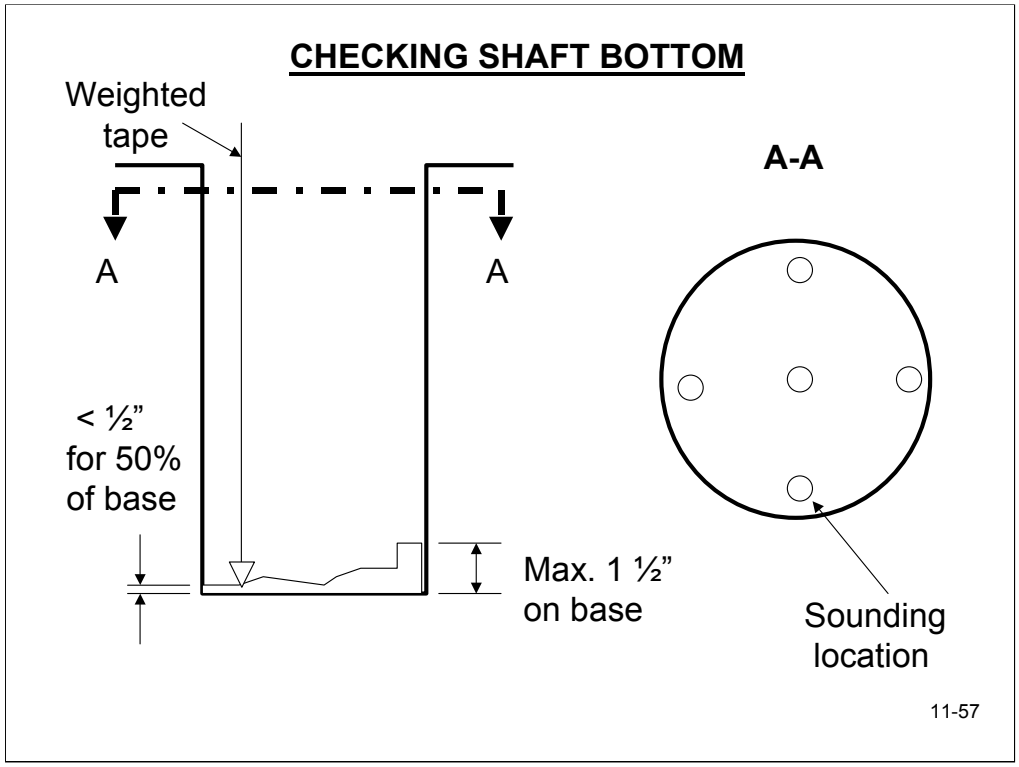
11-56

FHWA Publication IF-99-025

xxx.40 EXCAVATION INSPECTION

….The maximum depth of sediment or any debris at any place on the base of the shaft shall not exceed 1-1/2 inches (38 mm). Shaft cleanliness will be determined by the Engineer, by visual inspection for dry shafts or other methods deemed appropriate by the Engineer for wet shafts. In addition, for dry excavations, the maximum depth of water shall not exceed 3 inches (75 mm) prior to concrete pour.

For dry shafts, the sidewalls shall be visually free of cuttings that may have been smeared on the walls during the removal and insertion of drilling tools…



One of the most common methods to measure sediment on the bottom of the shaft is through the use of a weighted tape.

Following removal of the drilling tool, lower a weighted tape slowly down the hole until encountering the sediment or bottom. Take and record the measurement. The difference between that measurement and the shaft depth measurement made from the reference, provides the thickness of sediment on the shaft bottom.

Repeat this at four more locations around the shaft.

SHAFT INSPECTION DEVICES

11-58

This is a photograph of the first Shaft Inspection Device (down-hole-camera) used in the United States, in Florida.

The short video describes the down-hole-camera technique.

This device and the following smaller units are available from:

GPE, Inc.
4509 NW 23 Ave, Suite 16
Gainesville, FL 32606
888-399-2404
www.gpe.org

11-59

Photographs courtesy of GPE, Inc.

This is the DHC model shaft inspection device. Much smaller and much more economical and portable than the first generation.

Inside 36” rock socket

Clay filled cavity in sidewall of 36" rock socket.

Photographs courtesy of GPE, Inc.

Pictures of a camera in a 36” dia. rock socket and a photo of the rock socket taken with the down-hole-camera.

SHAFT CLEANLINESS

Commentary, xxx.41 Construction Tolerances

- In general the procedures for checking the bottom conditions of wet holes are crude, i.e. line devices or visual observation via video.

- Insistence by the engineer on the use of the proper cleaning tools for the site conditions is the best method to insure a clean bottom.

- Invariably, better cleanout can be achieved with air lifts and submersible pumps than with cleanout buckets.

11-61

FHWA Publication IF-99-025

xxx.41 CONSTRUCTION TOLERANCES

Commentary

The required degree of bottom cleanliness depends on design factors such as the percentage of load carried in base resistance and allowable settlement. In general the procedures for checking the bottom conditions of wet holes are crude, i.e., line devices or visual observation via video. Insistence by the engineer on the use of the proper cleaning tools for the site conditions is the best method to insure a clean bottom. Invariably, better cleanout can be achieved with air lifts and submersible pumps that with cleanout buckets.

SHAFT CLEANLINESS

Shaft cleanliness is important for:

A) end-bearing shafts

B) side-friction shafts

C) both of the above

D) none of the above

11-62

40. Did you complete the Shaft Inspection form?

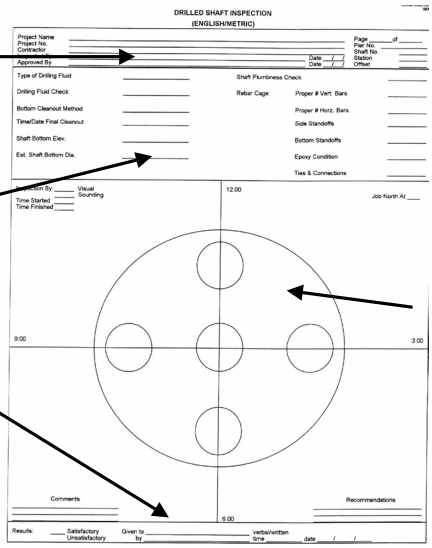
Completing the Drilled Shaft Inspection Log

Heading- Fill in before inspection starts

Shaft Status- Drill fluid check

Shaft Cleanliness- Check procedure being used

Record results



11-63

Full size version follows.

SAMPLE

DRILLED SHAFT INSPECTION

(ENGLISH/METRIC)

Project Name _____ Page _____ of _____
Project No. _____ Pier No. _____
Contractor _____ Shaft No. _____
Inspected By _____ Date ___/___/___ Station _____
Approved By _____ Date ___/___/___ Offset _____

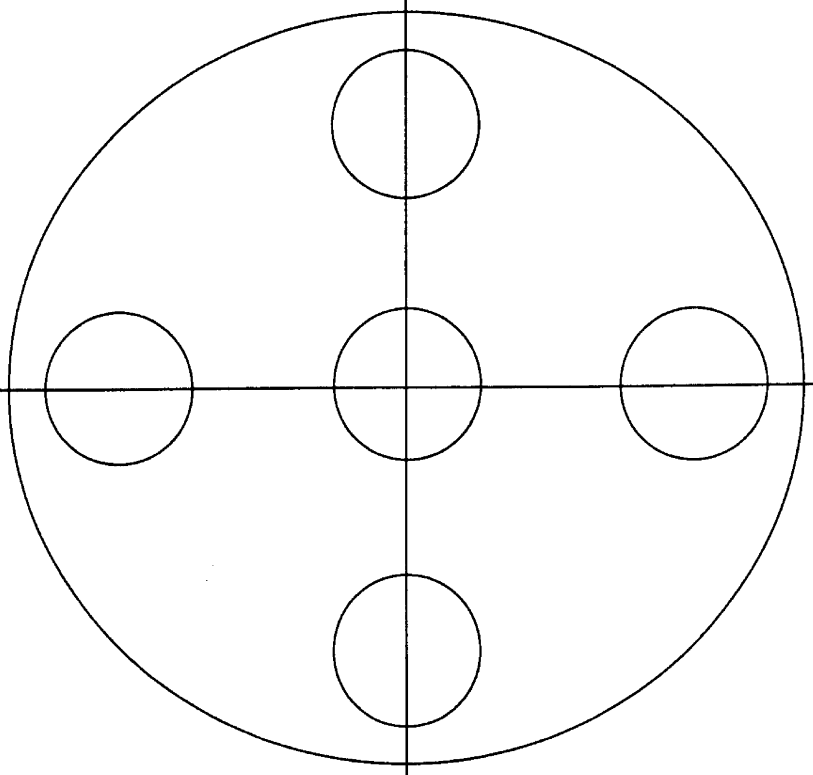
Type of Drilling Fluid _____
Drilling Fluid Check _____
Bottom Cleanout Method _____
Time/Date Final Cleanout _____
Shaft Bottom Elev. _____
Est. Shaft Bottom Dia. _____

Shaft Plumbness Check _____
Rebar Cage: Proper # Vert. Bars _____
Proper # Horz. Bars _____
Side Standoffs _____
Bottom Standoffs _____
Epoxy Condition _____
Ties & Connections _____

Inspection By: _____ Visual
_____ Sounding
Time Started _____
Time Finished _____

12:00

Job North At ____



9:00

3:00

6:00

Comments

Recommendations

Results: ____ Satisfactory
____ Unsatisfactory

Given to _____ verbal/written
by _____ time _____ date ___/___/___

TYPICAL PROBLEM

Dirty Hole

11-65

TYPICAL PROBLEMS

• ***Folded-in debris***- insufficient cleaning of the shaft, excessive sand being carried by the slurry.

• ***Soft shaft bottom***- incomplete bottom cleaning, side sloughing or sedimentation of cuttings from slurry column

11-66

This is a photograph of a defect on a highway bridge after contaminated concrete had been chipped away. A severe defect of this size can be detected with almost certainty by the sonic echo method.

LEARNING OBJECTIVE #3

Explain methods of assessing and verifying shaft cleanliness

The maximum depth of sediment or debris permitted anywhere on the shaft bottom is ___?

Describe a common non-intrusive method of determining shaft cleanliness.

11-68

LEARNING OBJECTIVES

- **Describe how to verify Checklist Questions 19-40**
- **Determine Shaft tip elevations**
- **Explain methods of assessing and verifying shaft cleanliness**
- **Describe the typical rock boring and shaft excavation log forms and their completion**

11-69

ANY QUESTIONS?

11-70